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Experiment Station

SPECIFIC GRAVITY AND WOOD MOISTURE VARIATION OF WHITE PINE

Abstract.—A report on results of a study to develop a means for estimating specific gravity and wood moisture content of white pine. No strong relationships were found by using either the single or combined factors of age and dimensional stem characteristics. Inconsistent patterns of specific gravity and moisture over height in tree are graphically illustrated.

The measurements most commonly employed in forestry to describe standing timber are tree age, diameter, merchantable height, and form class. If these measurements could be used to estimate specific gravity and moisture in the standing tree, then forestry cruise data could easily be transposed into quality and weight estimates for a given unit of area.

Results from a study of white pine (*Pinus strobus* L.) near Durham, New Hampshire, indicated that the use of age and stem dimensions as an expression of whole-tree properties accounts for too small a portion of the total variation to be seriously considered in prediction equations.

Methods

The procedure consisted of measuring age and diameter at breast height (d.b.h.), merchantable height (3-inch top), and Girard form class for a sample of 75 trees.[1] Trees were felled and cut into 8-foot sawlogs and 4-foot pulp bolts. A 1-inch cross-sectional disk was cut from the base of each section and at the top merchantable limit.

[1] Field data were collected by the author as part of Hatch 149 Project of the New Hampshire Agriculture Experiment Station.

Table 1.—Range and average of sample trees

Variable	Range	Average
Specific gravity	0.278–0.398	0.338
Moisture percent	78–187	137
Tree age, years	19–80	46
Tree diameter, inches	3.9–21.4	12.2
Merchantable height, feet	14–76	48
Form class	49–88	78

Specific gravity of the cross-section disks was computed on a green-volume[2] ovendry weight basis. Moisture content was determined as the difference between green and ovendry weight expressed as a percentage of ovendry weight. Specific gravity and moisture values presented on a tree basis were weighted in proportion to the bolt volumes making up the tree. Sample tree data are summarized in table 1.

The data were analyzed by a full-screen regression program, whereby tree specific gravity and moisture content were expressed as a function of all possible combinations of the independent variables listed in table 2.[3] All regressions were tested for significance at the 10-percent level, using the Scheffé conservative "S" test.[4] This test was used to assess significance on the basis of the buildup in the coefficient of determination as the number of regression components were increased.

Specific gravity and moisture determined from the cross-section disks were investigated graphically according to height in tree.

Results

Output from the full-screen program involved only the coefficients of determination. Table 2 gives the r-squares for specific gravity and moisture for the independent variables taken singly.

Specific gravity.—The most important single tree characteristic related to differences in specific gravity was found to be $1/A^2$. ($r^2 = 0.282$). Although significance is shown for most of the variables studied, it is obvious that no single factor is strongly related to the

[2] United States Forest Products Laboratory. METHODS OF DETERMINING THE SPECIFIC GRAVITY OF WOOD. USDA Forest Prod. Lab. Tech. Note B-14, 6 pp., 1956.

[3] Furnival, G. N. MORE ON THE ELUSIVE FORMULA OF BEST FIT. Soc. Amer. Foresters Proc. 1964: 7 pp.

[4] Scheffé, H. THE ANALYSIS OF VARIANCE. 447 pp. John Wiley and Sons, New York, 1959.

Table 2.—Coefficients of determination (r^2) for specific gravity and moisture content for each independent variable taken singly

	Independent variable	r^2	
		Specific gravity	Moisture content
X_1	Tree age (A)	0.228**	0.162
X_2	Tree diameter (DBH)	.157	.050
X_3	Merchantable height (MH)	.217**	.206**
X_4	Form class (FC)	.254**	.131
X_5	MH/A	.019	.019
X_6	DBH/A	.001	.027
X_7	$1/A^2$	.282***	.117
X_8	$1/MH^2$	.254**	.047
X_9	$FC^6 \times 10^{-8}$	.193*	.146
X^{10}	$[(FC)^6 \text{ Log } (A-19)]$	.242**	.196**

***Significant at 1 percent level.
**Significant at 5 percent level.
*Significant at 10 percent level.

specific gravity of white pine. On the basis of a significant improvement in explainable variability, none of the multiple regressions was superior to $1/A^2$. In fact, this variable alone accounted for 80 percent of the total variation in specific gravity explained by the maximum 10-variable model ($R^2 = 0.353$).

Moisture content.—Merchantable height was found to be the most important measurement in explaining tree-to-tree variability in percentage of moisture. ($r^2 = 0.206$). The only other significant factor was a model derived by combining a power transformation with a scaled transformation (X_{10}). However, in neither case is the coefficient of determination large enough to provide a reasonable expression of tree moisture. Beyond merchantable height, the additive effects of the other nine variables did not statistically improve estimating precision.

Height in tree.—Specific gravity and percentage moisture over height within the tree were plotted for three merchantable height classes (fig. 1 and 2). Specific gravity decreases from top of stump up to 8 feet, but fluctuates in the upper sections. Conversely, moisture increases in the basal section, but the pattern is inconsistent for the 64-foot height class. Above 8 feet, the average line for the three height classes levels off, then increases sharply in the top segments.

Figure 1.—The average (solid line) and range in specific gravity at successive heights above stump, for three height classes.

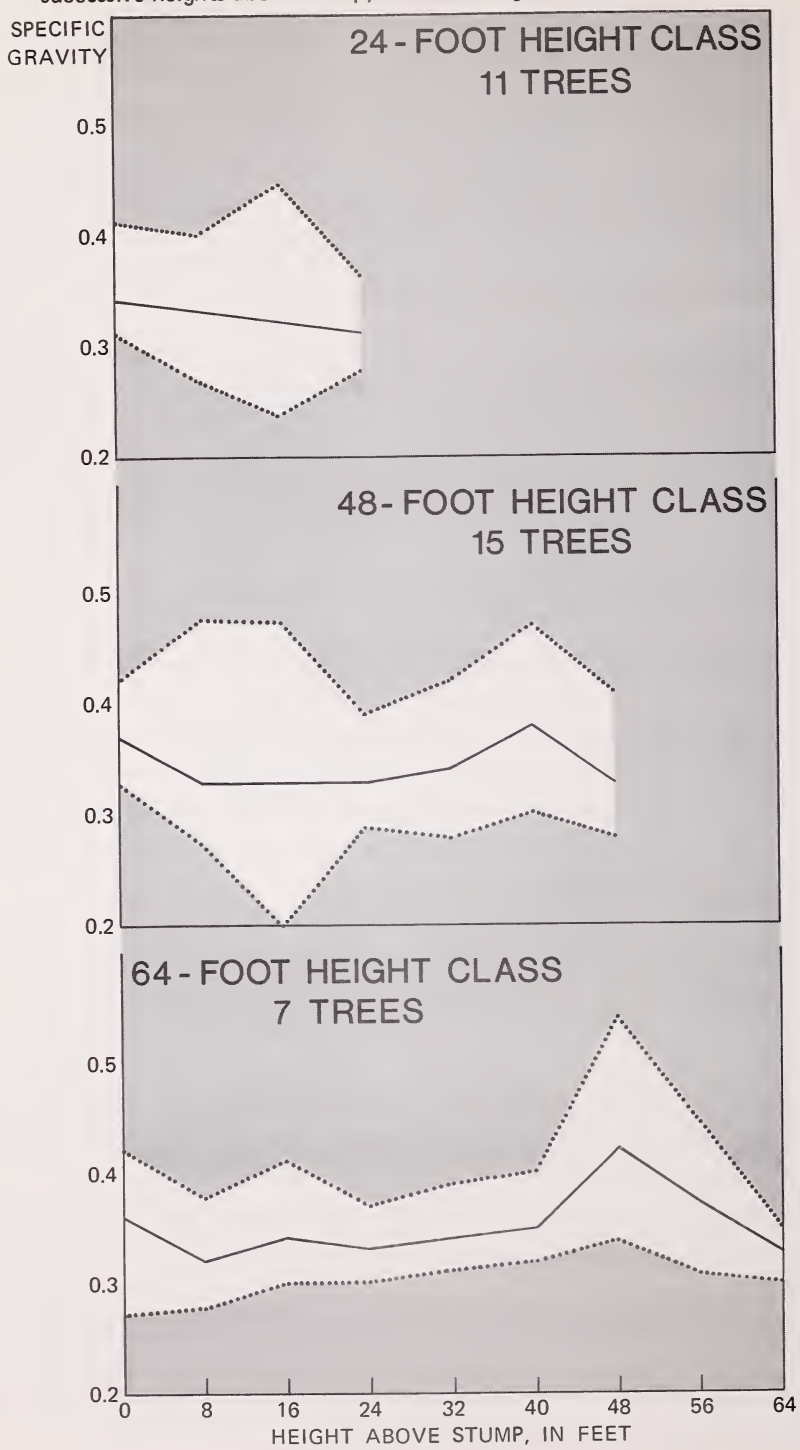
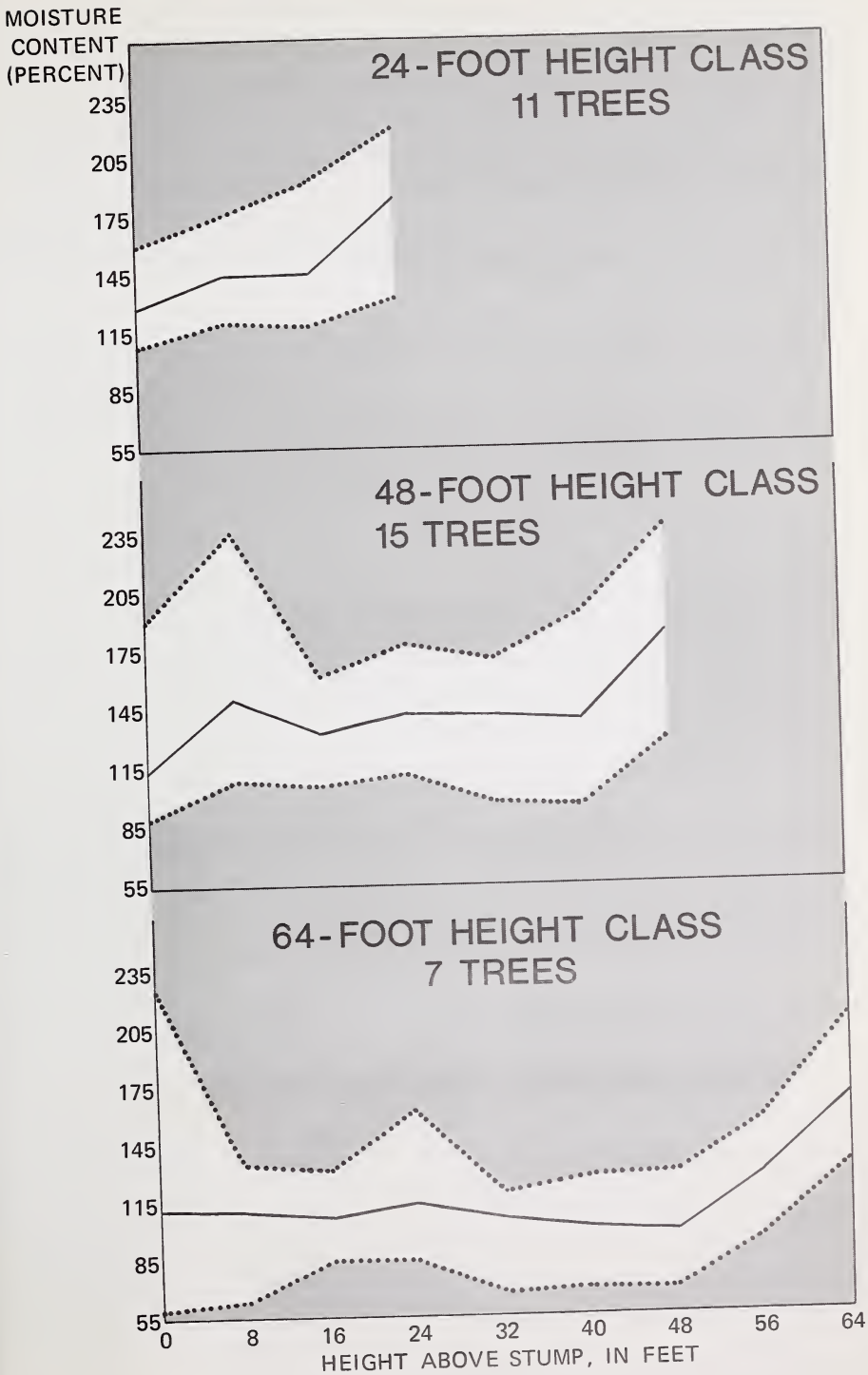


Figure 2.—The average (solid line) and range in moisture content at successive heights above stump, for three height classes.



Discussion

Results from this study have provided evidence of a wide range of variability in specific gravity and wood moisture of white pine. The rather small coefficients of determination illustrate that the forms selected to represent the relations may not have been appropriate. Or, there may be little or no relation of specific gravity and moisture to the independent variables chosen.

Before volume data can be transposed into quality and weight estimates, further basic research is needed to determine the roles of essential characters.

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